

AD\_\_\_\_\_

Award Number: DAMD17-00-1-0036

TITLE: The Role of  $\alpha\beta 6$ -Mediated Latent TGF $\beta$ 1 Activation in  
Prostate Cancer

PRINCIPAL INVESTIGATOR: .John S. Munger, M.D.

CONTRACTING ORGANIZATION: New York University School of  
Medicine  
New York, New York 10016

REPORT DATE: January 2003

TYPE OF REPORT: Final

PREPARED FOR: U.S. Army Medical Research and Materiel Command  
Fort Detrick, Maryland 21702-5012

DISTRIBUTION STATEMENT: Approved for Public Release;  
Distribution Unlimited

The views, opinions and/or findings contained in this report  
are those of the author(s) and should not be construed as an  
official Department of the Army position, policy or decision  
unless so designated by other documentation.

20030609 036

**REPORT DOCUMENTATION PAGE**Form Approved  
OMB No. 074-0188

Public reporting burden for this collection of information is estimated to average 1 hour per response, including the time for reviewing instructions, searching existing data sources, gathering and maintaining the data needed, and completing and reviewing this collection of information. Send comments regarding this burden estimate or any other aspect of this collection of information, including suggestions for reducing this burden to Washington Headquarters Services, Directorate for Information Operations and Reports, 1215 Jefferson Davis Highway, Suite 1204, Arlington, VA 22202-4302, and to the Office of Management and Budget, Paperwork Reduction Project (0704-0188), Washington, DC 20503

<b>1. AGENCY USE ONLY</b> (Leave blank)		<b>2. REPORT DATE</b> January 2003		<b>3. REPORT TYPE AND DATES COVERED</b> Final (1 Jan 00 - 31 Dec 02)	
<b>4. TITLE AND SUBTITLE</b> The Role of $\alpha$ v $\beta$ 6-Mediated Latent TGF $\beta$ 1 Activation in Prostate Cancer				<b>5. FUNDING NUMBERS</b> DAMD17-00-1-0036	
<b>6. AUTHOR(S)</b> John S. Munger, M.D.					
<b>7. PERFORMING ORGANIZATION NAME(S) AND ADDRESS(ES)</b> New York University School of Medicine New York, New York 10016  E-Mail: mungej01@med.nyu.edu				<b>8. PERFORMING ORGANIZATION REPORT NUMBER</b>	
<b>9. SPONSORING / MONITORING AGENCY NAME(S) AND ADDRESS(ES)</b> U.S. Army Medical Research and Materiel Command Fort Detrick, Maryland 21702-5012				<b>10. SPONSORING / MONITORING AGENCY REPORT NUMBER</b>	
<b>11. SUPPLEMENTARY NOTES</b>					
<b>12a. DISTRIBUTION / AVAILABILITY STATEMENT</b> Approved for Public Release; Distribution Unlimited					<b>12b. DISTRIBUTION CODE</b>
<b>13. ABSTRACT (Maximum 200 Words)</b> Abundant evidence suggests that overexpression of TGF $\beta$ by prostate cancer cells enhances their ability to grow and metastasize. TGF $\beta$ is secreted by cells in a latent form that results from a noncovalent interaction between TGF- $\beta$ and its propeptide (latency-associated peptide, LAP). Mechanisms leading to active TGF- $\beta$ are poorly understood at present. Our lab discovered a mechanism of TGF- $\beta$ activation in which the integrin $\alpha$ v $\beta$ 6 binds to an RGD sequence near the C-terminus of LAP. $\alpha$ v $\beta$ 6 is only expressed in epithelial cells. We hypothesize that $\alpha$ v $\beta$ 6, by activating TGF- $\beta$ 1, is an important regulator of normal prostate epithelial proliferation, and that overexpression of $\alpha$ v $\beta$ 6 by prostate tumor cells acts in concert with overexpression of its ligand latent TGF- $\beta$ 1 to produce active TGF- $\beta$ 1 and promote growth of the tumor. In this work, we are testing whether the $\beta$ 6 integrin subunit is regulated by androgen, whether it is overexpressed in human prostate cancer, and whether it affects growth and metastasis of prostate cancer in an animal model. Our results to date indicate that $\beta$ 6 expression is upregulated in the mouse in a delayed fashion after castration. We are now testing whether castration-induced prostate involution is affected by $\beta$ 6 by comparing normal and $\beta$ 6 KO animals, and producing mice that develop prostate cancer (TRAMP) that also lack $\beta$ 6 gene expression.					
<b>14. SUBJECT TERMS</b> prostate cancer, transforming growth factor- $\beta$ , integrin, TGF $\beta$ activation, PTEN, phosphatase, cell proliferation, epithelium				<b>15. NUMBER OF PAGES</b> 10	
				<b>16. PRICE CODE</b>	
<b>17. SECURITY CLASSIFICATION OF REPORT</b> Unclassified	<b>18. SECURITY CLASSIFICATION OF THIS PAGE</b> Unclassified	<b>19. SECURITY CLASSIFICATION OF ABSTRACT</b> Unclassified		<b>20. LIMITATION OF ABSTRACT</b> Unlimited	

NSN 7540-01-280-5500

Standard Form 298 (Rev. 2-89)  
Prescribed by ANSI Std. Z39-18  
298-102

## Table of Contents

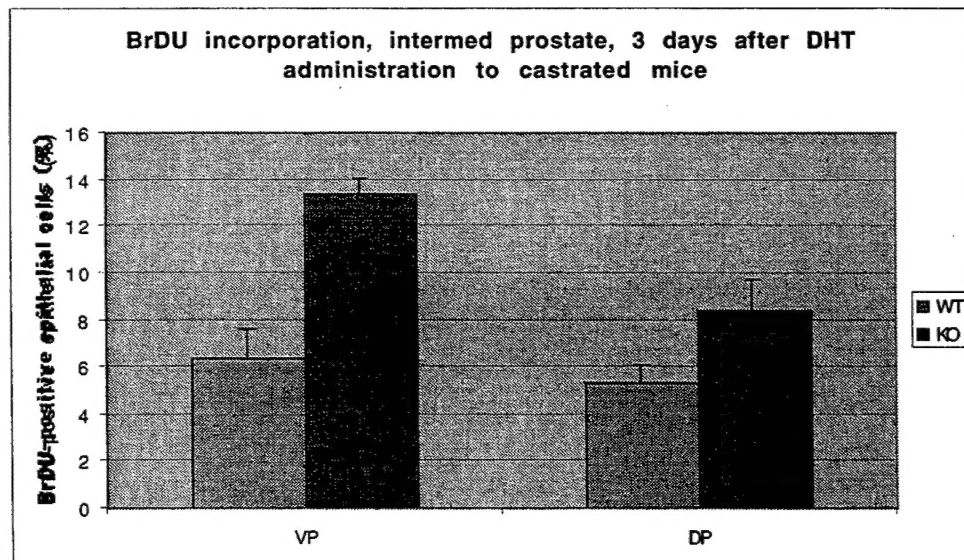
Cover .....	1
SF 298 .....	2
Table of Contents .....	3
Introduction .....	4
Body .....	5
Key Research Accomplishments .....	8
Reportable Outcomes .....	9
Conclusions .....	10
References .....	
Appendices .....	

## INTRODUCTION

The subject of this work is a system for the activation of latent TGF $\beta$  in the prostate. The system consists of the  $\alpha$ V $\beta$ 6 integrin expressed on epithelial cells. Our previous work showed that this integrin can bind to an integrin recognition site (arg-gly-asp) on latent TGF $\beta$ 1 and effect its activation. TGF $\beta$  is known to be important for regulating the growth and differentiation of various epithelia, and also to be important in cancer growth. Little is currently known about this system in the prostate: eg, what cells express  $\alpha$ V $\beta$ 6, how expression of the integrin is regulated, and if and when this system regulates prostate epithelial growth via production of active TGF $\beta$ 1. The purpose of the work is to demonstrate whether or not this system plays a role in prostate cancer. The scope of the work involves cell line and mouse experiments (to gauge the normal expression and regulation of  $\alpha$ V $\beta$ 6 in the prostate), and evaluation of human prostate cancer tissue and an *in vivo* mouse prostate cancer model (to address the question, does  $\alpha$ V $\beta$ 6-mediated activation of TGF $\beta$ 1 promote prostate cancer growth?).

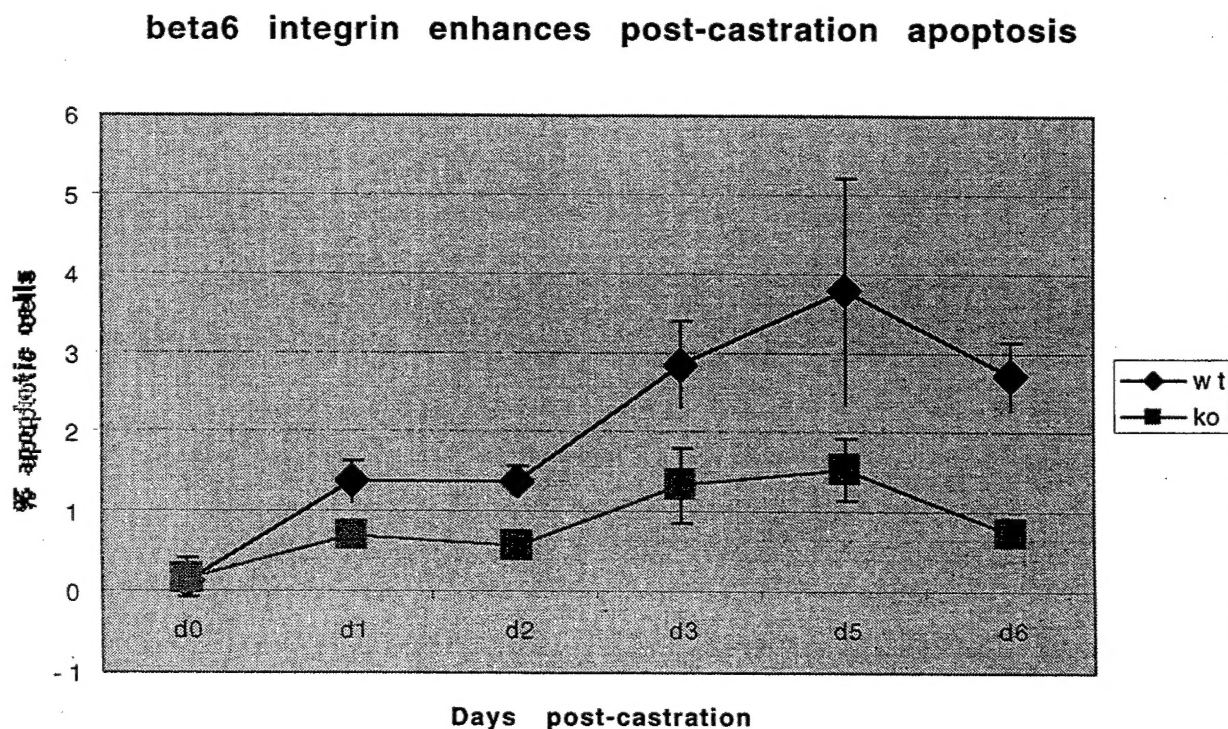
## Body

1. We determined avb6 integrin expression in mouse and human prostate. avb6 is not expressed in resting mouse prostate except for low levels in proximal ducts. After castration, avb6 is readily detectable at 48 h in a patchy distribution - ie, some lumens are stained and others are negative. By 7 days post-castration, avb6 expression is more uniform. (We looked at functional differences between b6+ and b6- ducts as discussed below). In human prostate, avb6 is expressed uniformly in basal cells and in atrophic epithelium. However, it is virtually absent in all cancers we examined.
2. Although avb6 is upregulated after castration, we did not find that androgen altered the level of avb6 expression in 2 prostate epithelial cell lines examined (from Dr. EL Wilson). A luminal cell line expresses avb6 (and activates TGFb), and a basal cell line does not express avb6. Neither pattern of avb6 expression in the presence or absence of DHT in the culture medium. Our hypothesis is that androgen withdrawal leads indirectly to avb6 upregulation in the prostate.
3. We use b6-/- mice to measure the effect of avb6 (and resulting TGFb activation) on prostate epithelium proliferation. At baseline in adult animals, BrDU incorporation is very low and no difference was seen between wild type and b6-/- animals. Additional animals were castrated (to induce high avb6 expression). Ten days after castration, animals were treated with androgen (DHT) to stimulate rapid growth of prostate. At 3 days post androgen replacement, BrDU incorporation was markedly increased, as expected, and was about 2-fold higher in b6-/- than in wild type. This result is consistent with endogenously activated TGFb being present in the wildtype mice and acting as a brake on proliferation. This is the first example of avb6 regulating epithelial cell growth via TGFb activation.

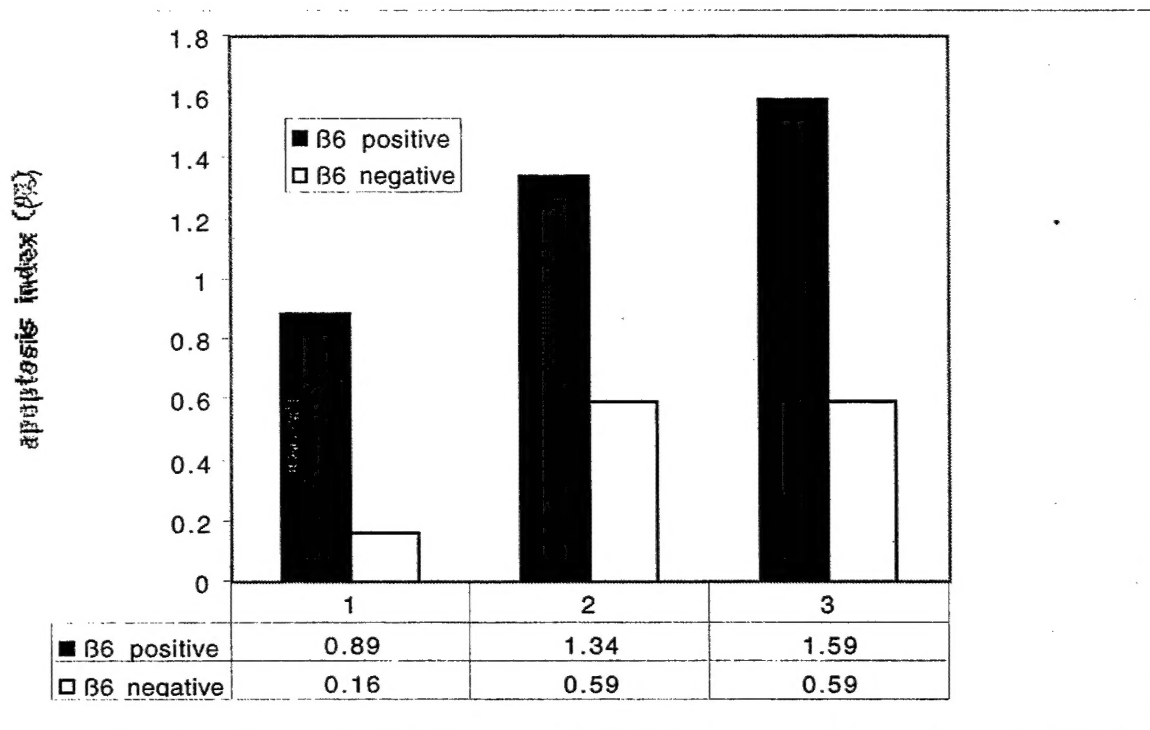


4. PTEN is reported to influence integrin function by acting as a phosphatase for integrin-interacting proteins like FAK. However, in experiments in which we transfected cells with sense and antisense PTEN sequences, we found no evidence that PTEN expression alters TGFb activation by avb6.

5. We failed in our attempt to determine the influence of avb6 on a mouse model of cancer. The idea was to cross TRAMP mice, which express an oncogene in the prostate and develop prostate cancer, with b6<sup>-/-</sup> and see if the absence of avb6 affects growth of the primary tumor and/or metastases. The problem was that the TRAMP/b6<sup>-/-</sup> mice bred very poorly. Littermate wildtype TRAMP mice that we bred did well. However, although we managed to generate about 8 breeding pairs of b6<sup>-/-</sup> and TRAMP/b6<sup>-/-</sup> mice, litters were rarely produced and when pups appeared they generally wasted and died. One problem may have been pathogens. At the start of the experiment, the mice were housed in a specific pathogen-free facility. However, the facility developed a murine hepatitis virus infection and breeding was halted in the facility for ~ 6 months. To continue our experiment, we were forced to transfer our mice to another non-pathogen free facility where we could continue to breed. The cross may have been unexpectedly susceptible to pathogens there; wild type, TRAMP and b6<sup>-/-</sup> mice continued to breed well, but TRAMP/b6<sup>-/-</sup> mice bred with b6<sup>-/-</sup> mice did not. We are still hoping to complete this experiment but will have to re breed from the beginning in a clean facility. It is also possible that an unexpected genetic abnormality in TRAMP/b6<sup>-/-</sup> mice prevents breeding regardless of pathogens.
6. We did additional characterization of the effects of avb6-mediated TGFb activation in mouse prostate not originally proposed. Since TGFb is alleged to be an inducer of apoptosis in prostate after castration, we measured the rate of apoptosis as a function of time after castration in WT and b6<sup>-/-</sup> mice. Apoptosis was measured by TUNEL by a blinded observer. We found that the rate of apoptosis in b6<sup>-/-</sup> is consistently only ~half that of wildtype mice. This is consistent with avb6-mediated TGFb activation in post-castration prostate influencing apoptosis. Differences are significant at all time points except day 5. We also



compared the rate of apoptosis in lumens expressing avb6 and lumens not expressing avb6, at 2 days post-castration in wild-type mice. We did this by using serial sections for b6 immunohistochemistry and for TUNEL. (Recall that early after castration we found that avb6 expression is heterogeneous). In this case, apoptosis rate was ca. 3-fold higher in b6+ lumens than in b6- lumens. This results strengthens the previous result because it eliminates the possibility of an irrelevant difference in b6-/- and b6+/+ mice accounting for the difference in apoptosis. Finally, we directly measured active TGFb in supernatants of homogenized prostate tissue 4 days post-castration and found a significant increase in wild type compared to b6-/- mice.





## Key Research Accomplishments

- First description of b6 expression in normal and malignant human prostate and in murine prostate.
- Evidence that b6 expression in prostate is indirectly regulated by androgen.
- Evidence that avb6 in prostate activates TGFb that regulates prostate epithelial proliferation and apoptosis.
- PTEN is not involved in regulating TGFb activation by avb6



### Reportable Outcomes

1. Two manuscripts are being prepared (on the effects of avb6 on murine prostate apoptosis and proliferation, and on b6 expression in normal and malignant human prostate).
2. Animal model: TGFb effects quantifiable by measurements of post-castration apoptosis and androgen-induced exvolution.
3. I plan to apply for additional grant funds to study mechanisms involved in regulating b6 gene expression in prostate.

## Conclusions

Avb6-mediated TGFb activation in the prostate can regulate epithelial cell proliferation and apoptosis in murine prostate. In humans, the presence of avb6 in basal cells (not seen in mice) suggests that TGFb activation might be important in suppressing the proliferation of these cells. The results in mice suggest that hormonal therapy in humans might increase avb6 expression and result in increased TGFb activation. This might have positive or negative effects on tumor growth and metastasis.